TRANSMISSION OBJECTIVES

CONTENTS

1. GENERAL

1.1 This section provides REA borrowers, consulting engineers, contractors and other interested parties with technical information about transmission objectives for use in the design and construction of telephone systems for REA borrowers.

1.2 This revision replaces REA TE&CM 415, Issue No. 3, dated March 1962 and is reissued to reflect changes in design objectives. The significant changes include a reduction in the permissible 1000 Hz loss of trunks and subscriber lines, a widening of the voice frequency response objectives and an improvement in the idle circuit noise requirements (see Tables A, B and C). Objectives for other parameters important to data transmission such as delay distortion, frequency shift and nonlinearity are not covered in this section. However, their affects should be considered and are presently under study. Central office connector loss, formerly included in the subscriber line, has been assigned to the interoffice trunks.

1.3 Speech transmission capability is one of the principal concerns in telephone system design. After a circuit has been established between two subscribers, adequate speech transmission is essential regardless of their respective locations. From their viewpoint, it would be better that the circuit not be completed if they are unable to communicate satisfactorily.

1.4 The primary transmission objective is to provide quiet, low loss, good quality circuits between subscribers, whether they be within the same exchange area or at different locations in the nation or the world. A maximum of about ten trunks may be involved between end offices on the North American continent. Added to this possible combination are the respective subscriber lines at each end of the connection. Because of the enormous distances that may be involved and the relatively slow velocity that speech signals may undergo through some circuits, the controlling factor over the amount of signal gain that can be applied to the circuit is the echo of the subscriber's voice or, at worst, "singing," both of which are conditions produced by impedance irregularities somewhere along the circuit. Consequently, all trunks must be designed to operate at the lowest loss practicable in a manner that will permit no objectional echo or singing when any combination of trunks is used to form the connection.

2. INTEROFFICE TRUNKS

2.1 Extensive tests have been conducted by the Bell Telephone Laboratories to determine the lowest permissible loss at which various types of trunk facilities may be operated based on the amount of echo subscribers will tolerate. From these tests it has been determined that a discrete value of loss may be assigned to a specific facility based on its type and length. The lowest loss at which a circuit may operate without objectionable echo is called VIA Net Loss (VNL). The value of loss allowed for any given length is determined by applying the VIA Net Loss Factors (VNLF) applicable to the types of circuits involved. A comprehensive explanation of VIA Net Loss is included in "Notes on Distance Dialing," by the American Telephone and Telegraph Company. Copies may be obtained from Bell System telephone company offices.

2.2 For toll terminating trunks up to 100 miles in length, the transmission loss objective can be accurately expressed as a fixed loss. The new objective is 3 dB including the loss contributed by the central office equipment (Figure 1 and Table A).

3. SUBSCRIBER LINES AND PBX/PABX TRUNKS

3.1 Subscriber lines and PBX/PABX trunks normally contribute most of the total circuit loss in a switched connection even though they are relatively short in length. This condition makes them the controlling links and therefore, equal in importance to trunks in transmission design considerations.

3.2 Subscribers located at the greatest distance from the central office generally are receiving the poorest service because of poor transmission. This problem becomes more apparent when there are many subscribers, particularly businesses, located in an area that falls in this category. New housing developments and shopping centers are rapidly springing up in remote areas and marginal transmission can no longer be tolerated.

3.3 The new transmission objectives, 8 dB for subscriber lines and 5 dB for PBX/PABX trunks, will improve this situation by enabling many of these subscribers to enjoy the same quality telephone service that those nearer the switching centers have been receiving. This does not suggest that the lower objectives alone will solve the problem. The noticeable improvement will be realized by many subscribers who will be assigned to better transmission zones using new system designs incorporating transmission improvement techniques.

3.31 Transmission improvement in the order of 6.5 dB can be realized quite economically on certain lines using Common Mode Operation (CMO) which can be arranged to include many of these subscribers.

3.32 Station carrier can readily provide excellent transmission to the most distant subscribers.

3.33 Subscriber radio link equipment can fulfill the requirements of the most inaccessable subscribers because of terrain and geographic isolation.

3.34 More careful attention in locating load coils, omitting non-working bridge taps, bridging ringers and in using gain devices along with improved construction practices can provide marked improvement in telephone service to all subscribers without incurring serious economic penalties.

4. NET LOSS AND FREQUENCY RESPONSE

4.1 Circuit net loss is perhaps the most important transmission characteristic to the subscriber. This net loss, measured at 1000 Hz in this country, must be as low as possible in order for the listener to enjoy the benefit of good transmission; however, too little loss can result in a totally unacceptable condition to the talker and listener if echo or singing occur.

4.2 Modern telephony must provide the listener with good volume and also recognition of the talker. The latter is a function of the circuit's frequency response (attenuation distortion).

4.3 Details covering the design of two-wire physical toll connecting trunks and EAS trunks are in TE&CM Section 446, "Design of Two-Wire D66 Loaded Negative Resistance Repeatered Trunk Plant." Details covering the design of two-wire physical subscriber loop plant are in TE&CM Section 424, "Design of Subscriber Loop Plant."

4.4 Carrier derived trunks can be set to the prescribed net loss by a simple adjustment or the use of fixed loss pads. Carrier derived subscriber circuits are generally factory adjusted to a fixed loss within the limits specified. Details covering the design of trunk and subscriber carrier plant are in the 900 series of the TE&CM.

4.5 The 1000 Hz net loss and frequency response objectives are set forth in Table A.

5. NOISE

5.1 With lower net loss and improved frequency response the unwanted signals (noise) become increasingly important. Customer toll dialing deprives the subscriber of operator assistance in avoiding unsatisfactory circuits which means that a higher percentage of usable circuits must be in optimum condition at all times. Certain objectives which in the past were often difficult to meet are now requirements of connecting companies for allowing circuits to be turned-up for service.

5.2 Noise is generally categorized as (1) steady state, and (2) impulse. Steady state noise is the most objectionable in message circuits and is usually characterized as hum or hiss, whereas impulse noise is more detrimental to data transmission because it consists of pops and clicks that look like data to the data communications equipment.

5.3 Steady state and impulse noise objectives are given in Table C. The values are expressed in dBrn using C-message weighting for both types of noise.

6. CENTRAL OFFICE CONSIDERATIONS

6.1 Switching centers ideally should be electrically transparent; that is, they should not cause level changes or impedance mismatches in the circuits they switch. However, they introduce some attenuation and impedance discontinuity. But irrespective of this, they are classified as the impedance value which agrees with the average impedance of the types of circuits they switch.

6.2 The design characteristic impedance of all types of trunks switched by class 4 offices and higher is 600 ohms; hence, these offices are classified as 600 ohms with the exception of the Crossbar Tandem Office which is 900 ohms.

6.3 EAS trunks, PBX and PABX trunks and subscriber loops are designed for 900 ohms characteristic impedance; hence, local or class 5 offices that switch these circuits are classified as 900 ohm offices.

6.4 The introduction of attenuation and impedance discontinuity by the central office, though usually slight, must be considered and accounted for to provide the desired transmission objectives of the overall circuit.

6.5 Central office losses may vary from 0.5 dB to 1.7 dB, depending on the type of trunk circuits. Carrier derived trunks will have approximately 0.5 dB of loss which is contributed by the connector. Physical trunks with E&M signaling require a repeating coil at each end which contributes approximately 0.5 dB for a 1:1 ratio and 0.7 dB for 1:1.5 ratio or 1.2 dB plus 0.5 dB in the connector for a total of 1.7 dB. This does not include office wiring which contributes negligible loss except in large offices. The connector loss occurs only in the terminating office; therefore, for any circuit switched through two or

more offices, that portion of the trunk circuit within an end office will have 0.5 dB more loss in the terminating office than in the originating office. The total loss, however, will be equal in both directions of transmission because the 0.5 dB connector loss is in the two-wire transmission path of the subscriber loop. This must be taken into account when aligning terminating trunks to their correct losses. Since the connector loss is included in the trunk design, subscriber lines and PBX/PABX trunks do not include central office losses except where long line adapters are used in which case 0.5 dB is included. Figures 1, 2 and 3 illustrate how these losses are distributed.

6.51 Circuit losses can be overcome by gain devices such as VF repeaters and the amplification inherent in carrier equipment.

6.52 A large portion of the loss can be eliminated from the office and the impedance balance improved by not having unnecessary wiring, bridging devices and, particularly, repeating coils for deriving A and B leads. When A and B leads are required for switching carrier derived trunks, they must be derived within the four-wire terminating units associated with the carrier equipment. Repeating coils should be used only when impedance transformations or signaling leads, or both, are required for physical circuits.

6.53 The impedance continuity permitted by a switching office is called balance which is a measure of the similarity of the impedances of the four-wire terminating units (or their equivalents) of the trunks connected or switched at that office. It is expressed in decibels as echo return loss (ERL) and singing point (SP).

a. Terminal balance is a term associated with a class 4 office that switches an intertoll trunk to a terminating or toll connecting trunk.

b. Through balance is a term associated with higher class two-wire switching offices that switch two intertoll trunks together for a connection through to another toll office.

6.54 Office terminal balance objectives are given in Table B.

7. TRANSMISSION CIRCUIT DEFINITIONS

7.1 A facility is a term often used to describe a specific type of plant or equipment or a combination of the two. For example, a facility may consist of a 19 or 22 gauge cable pair (loaded or unloaded). Coaxial cable and microwave radio are examples of wideband facilities. The carrier frequency voice channels multiplexed over cables or radio are also referred to as facilities.

7.2 A trunk may consist of one or a combination of facilities which extends from the outgoing side of a switch in a given central office to the outgoing side of a switch in the next central office. The trunk loss includes the central office losses. (Figure 1)

7.3 Intertoll Trunks (ITT) interconnect class 4 offices (toll centers and toll points) with other class 4 offices and higher ranking offices.

7.4 Toll Connecting Trunks (TCT) connect the class 5 office (end office) with a class 4 or higher ranking office at which access is made to the nationwide toll system. These trunks are usually arranged in groups for signaling one-way outward, one-way inward and two-way (inward and outward).

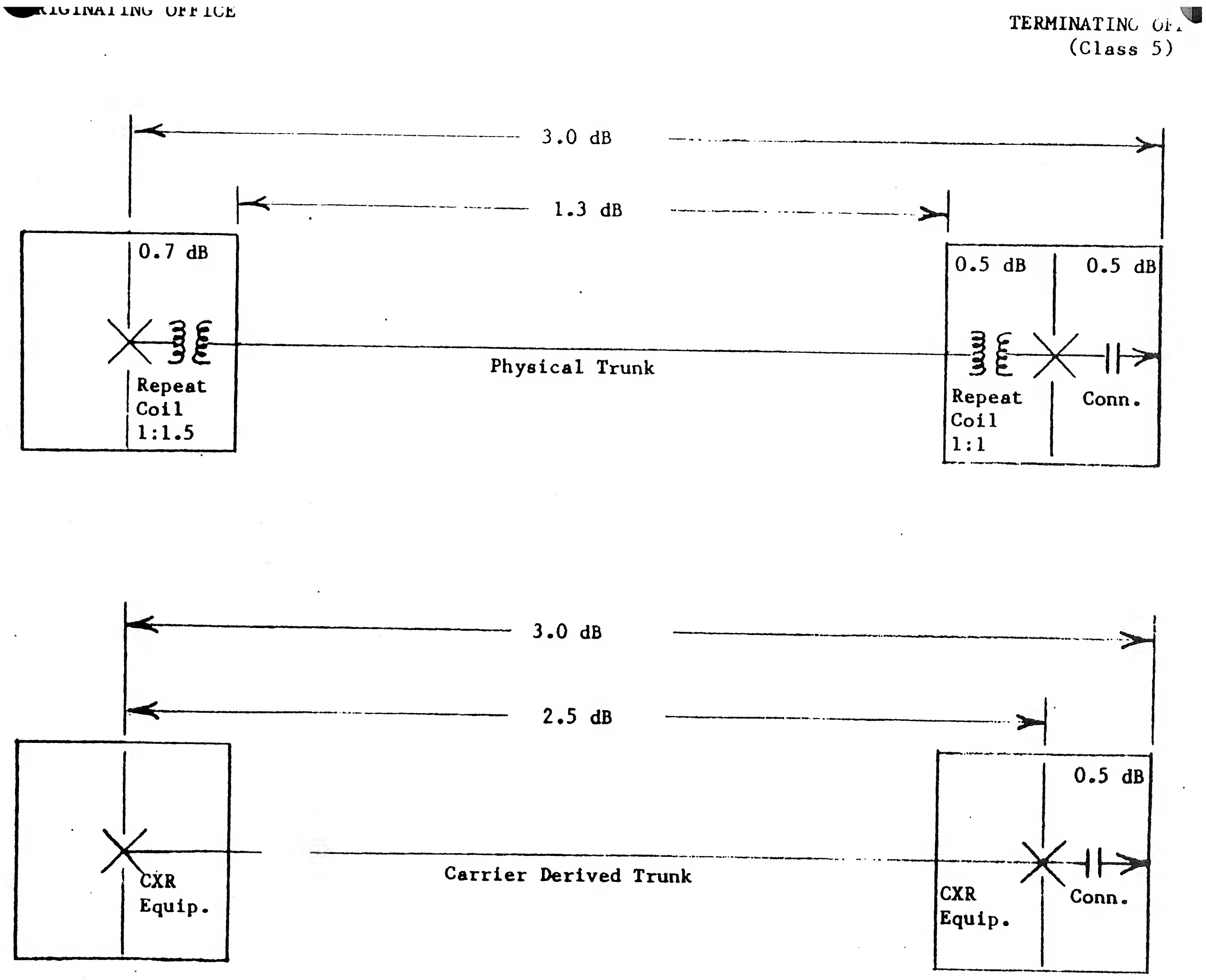
7.5 Nontoll Connecting Trunks are commonly categorized as:

7.51 Extended Area Services (EAS) trunks connecting class 5 offices without a toll charge.

7.52 Interoffice trunks providing special services such as information, operator assistance, repair service, intercept, verification, etc.

7.6 PBX or PABX trunks connect the class 5 office to the private branch exchange (PBX) or private automatic branch exchange (PABX) located on a customer's premises. (Figure 2)

7.7 Subscriber Line connects the subscriber's telephone to the class 5 office. It can be made up of a facility or combination of facilities similar to the composition of trunks. It can be derived from station carrier or a radio link but does not include the telephone instrument. It is commonly called a subscriber loop--a name derived from a physical facility which consists of two conductors that form a "loop" between the central office and the telephone instrument. (Figures 3A, 3B, 3C)



- TRUNK LOSS DISTRIBUTION

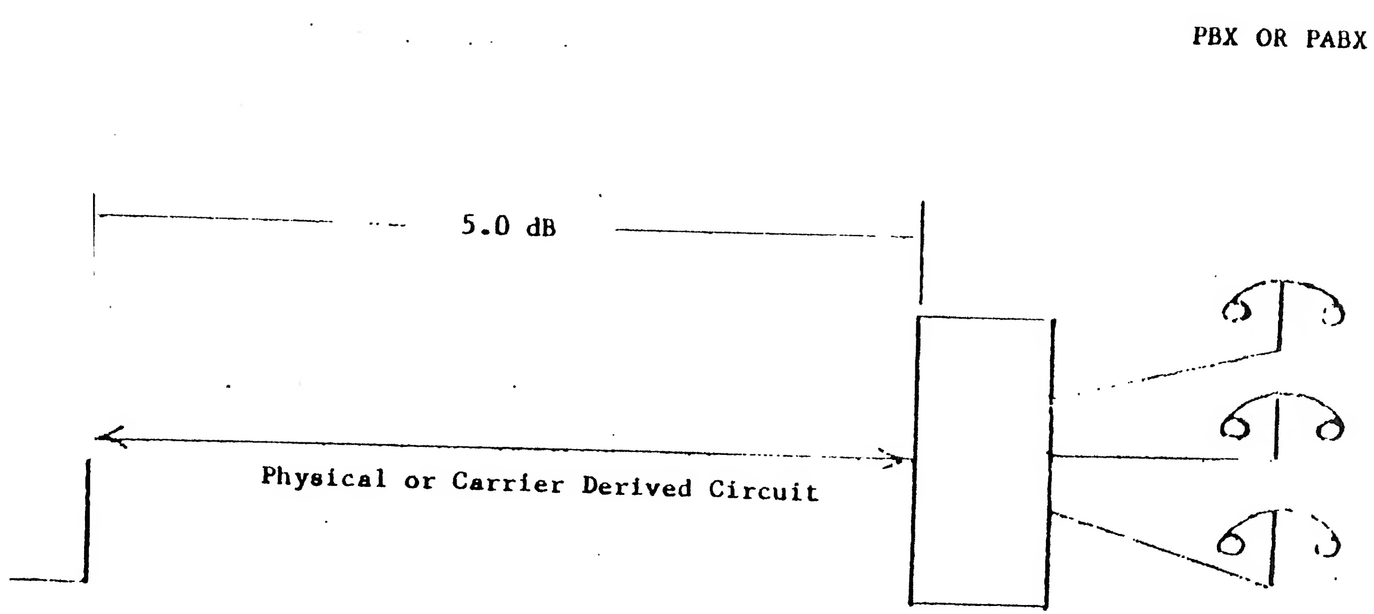


FIGURE 2 - PBX/PABX TRUNK

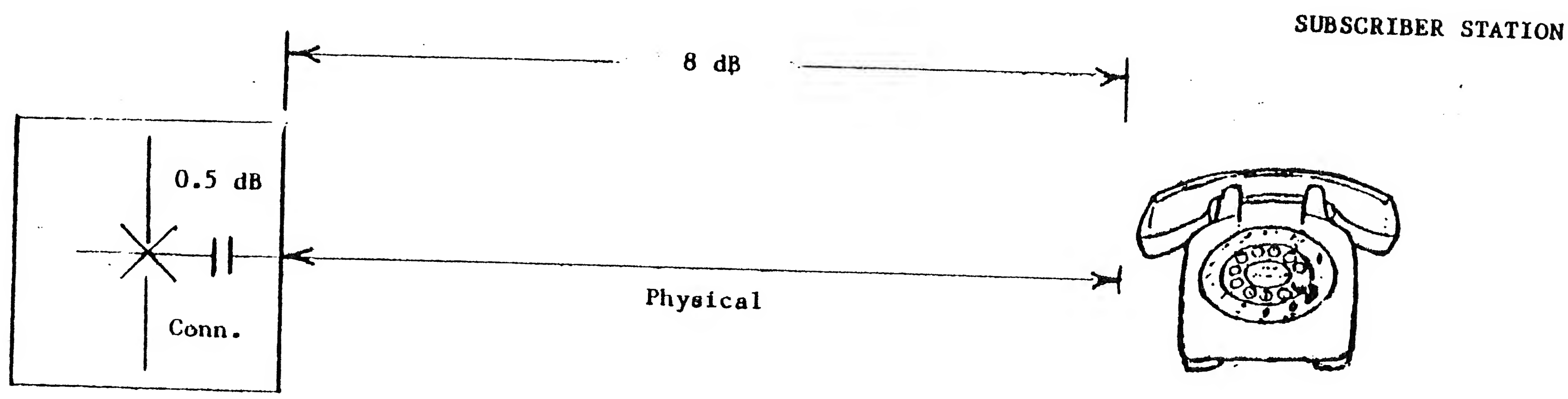


FIGURE 3A - SU[illegible]ER LINE-PHYSICAL

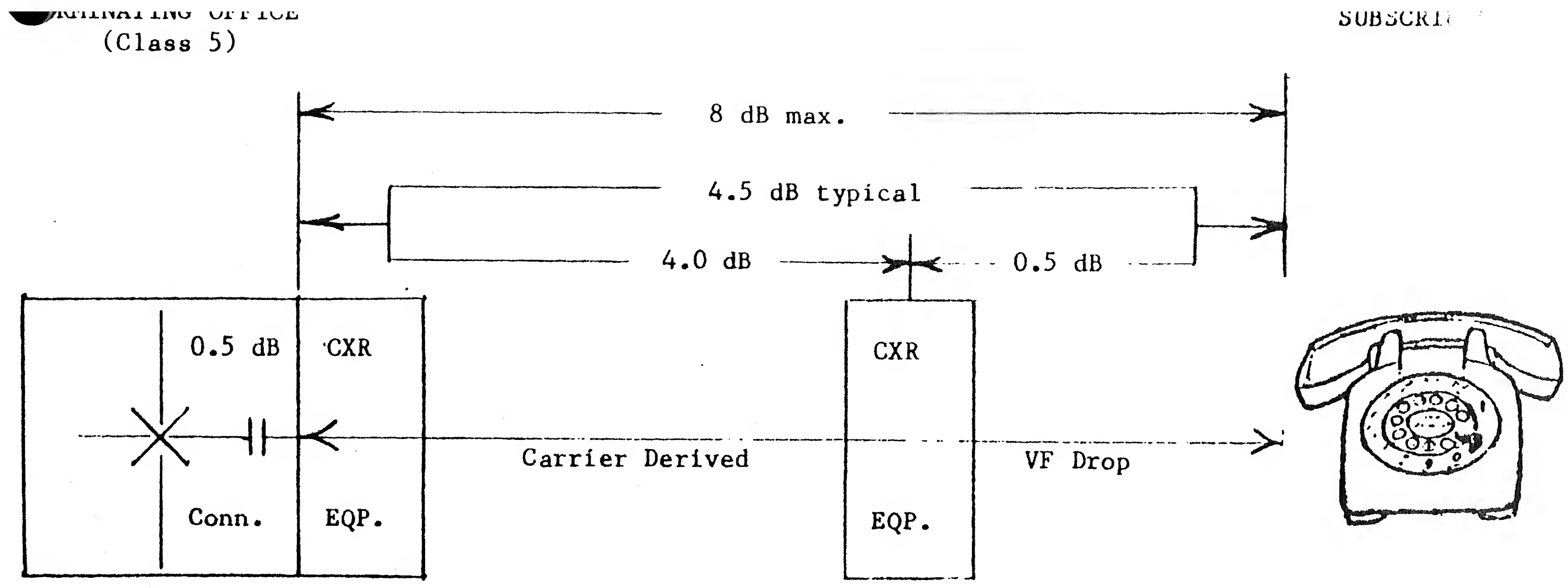


FIGURE 3B - SUBSCRIBER LINE-CARRIER DERIVED

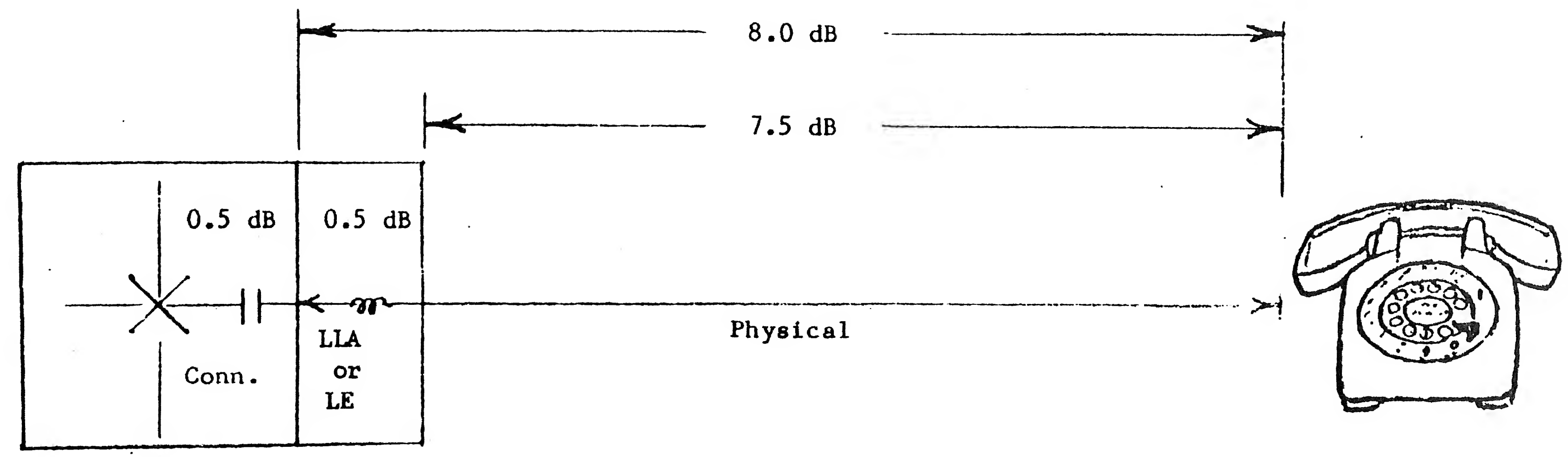


FIGURE 3C - SUBSCRIBER LINE-PHYSICAL WITH LONG LINE ADAPTER

TABLE A

Circuit Net Loss and Frequency Response Objectives

Type of Circuit	1000 Hz Net Loss*	Frequency Response Ref. to 1000 Hz	Comment
Intertoll Trunks	VNL	+1, -3 dB, 300 to 3400 Hz +1, -1 dB, 600 to 2400 Hz	Notes 1 & 2
Toll Connect. Trunks	3 dB Obj. 4 dB Max.	"	Note 2
Non-Toll Trunks	3 dB Obj. 4 dB Max.	"	Note 2
Subscriber Lines	8 dB	+1, -3 dB, 300 to 3200 Hz	Note 3
PBX and PABX Trunks	5 dB	"	Note 3

*Toll and non-toll trunk losses include central office loss. Subscriber line and PBX/PABX trunk losses do not include central office loss.

NOTES:
1. Coordinate with connecting company.
2. Should be no less than 3 dB down at 300 and 3400 Hz from 1000 Hz reference level. A roll-off at these frequencies is generally desirable though not required.
3. High frequency roll-off on physical circuits may occur at less than 3200 Hz depending on the facility, i.e. nonloaded, loaded, type of end section, etc.

TABLE B

Terminal Balance Objectives (Minimum)

	Physical Trunks	Carrier-Multiplex Trunks
ͻ Return Loss (ERL)	18 dB	23 dB
ging Point (SP)	10 dB	15 dB

Steady State and Impulse Noise Objectives (Maximum)

Plant Item	Steady Noise*		Comments	Impulse Noise*	Comments
Subscriber Lines	20 dBrnc		Note 1	52 dBrnc	Notes 1 & 2
PBX/PABX Trunks	20 dBrnc		Note 2	52 dBrnc	Notes 2 & 3
Toll and EAS Trunks	0 to 50 mi.	51 to 100 mi.	Note 4	0 to 100 mi.	Note 5
Physical (VF)	31 dBrnc0**	32 dBrnc0**		54 dBrnc0**	
Non-Comp. & PCM CXR	31 dBrnc0**	32 dBrnc0**		58 dBrnc0**	
Compandored CXR	26 dBrnc0**	27 dBrnc0**		66 dBrnc0**	Note 6
Central Office Equip.					
Direct Control	--		Note 7	--	Note 7
Common Control	16 dBrnc		Note 8	53 dBrnc	Note 9

*Noise values are stated in dBrn ith "C"-message weighting which is 1 dB less than with voice (VB) weighting.

**Based on 3 dB net loss.

NOTES:

1. Measured at line term ^ ^f telephone set.
2. Measured at line term PBX/PABX.
3. Impulse noise thresho more than 15 counts in 15 minutes.
4. Noise values on toll ^e connecting company requirements.
5. Impulse noise thresho ore than 5 counts in 5 minutes during the busy hour on at least 50 percent of the tru up based on 100 percent investigation. (For a single channel use limit of 15 counts in)
6. Measured while using ding tone.
7. Objectives have not b hed.
8. Measured at MDF with ched through to a quiet termination.
9. Impulse noise thresho re than 5 counts in 5 minutes during busy hour on at least 50 percent of the mea de on circuits switched through to a quiet termination.